"Multispecies" models to describe large neuronal networks

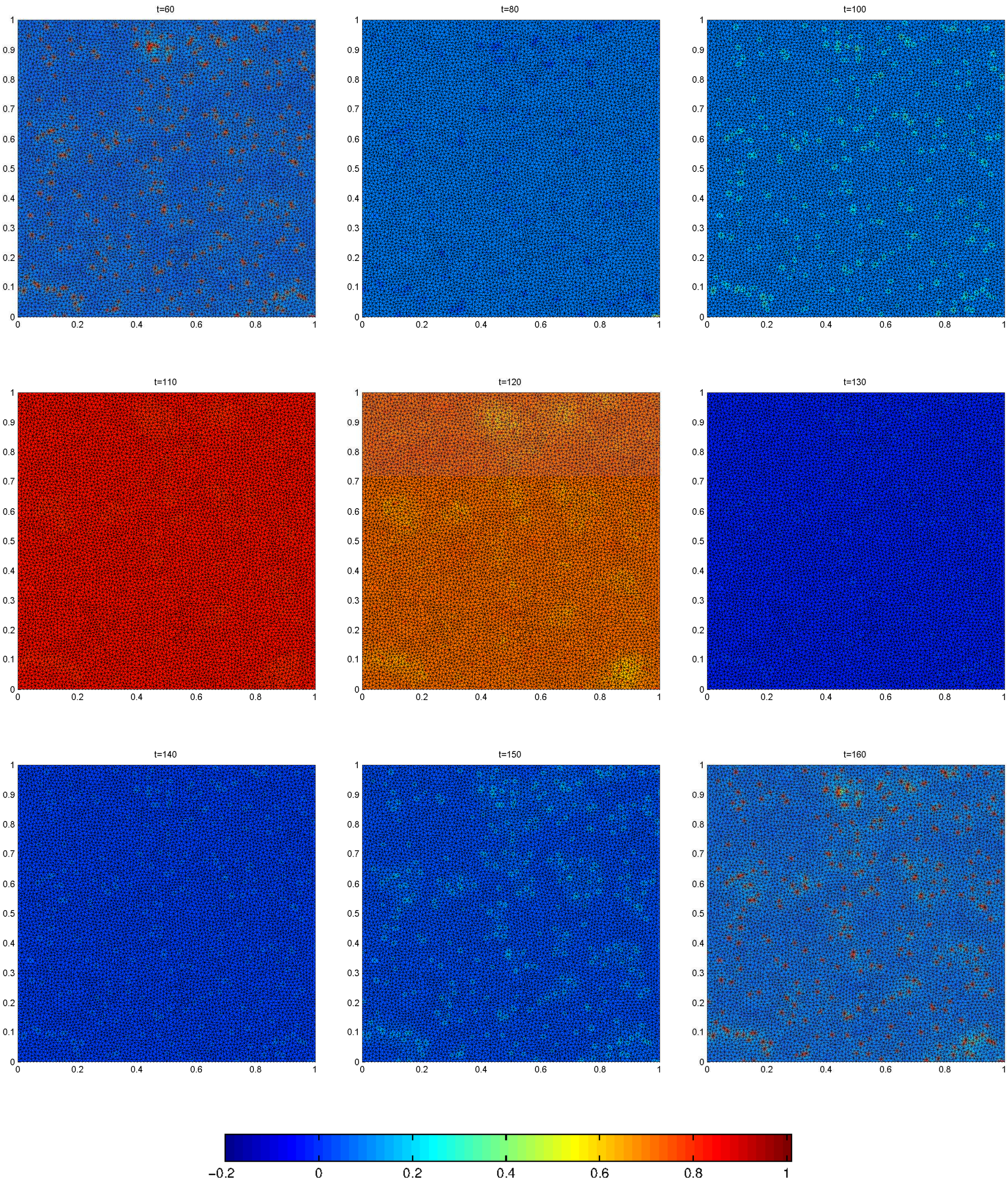

Figure 4.8: Final stages of the solution exhibited in Figure 4.6-4.7. Due to random links which facilitate communication between neurons in the whole domain, it can be seen that a new synchronous event emerges

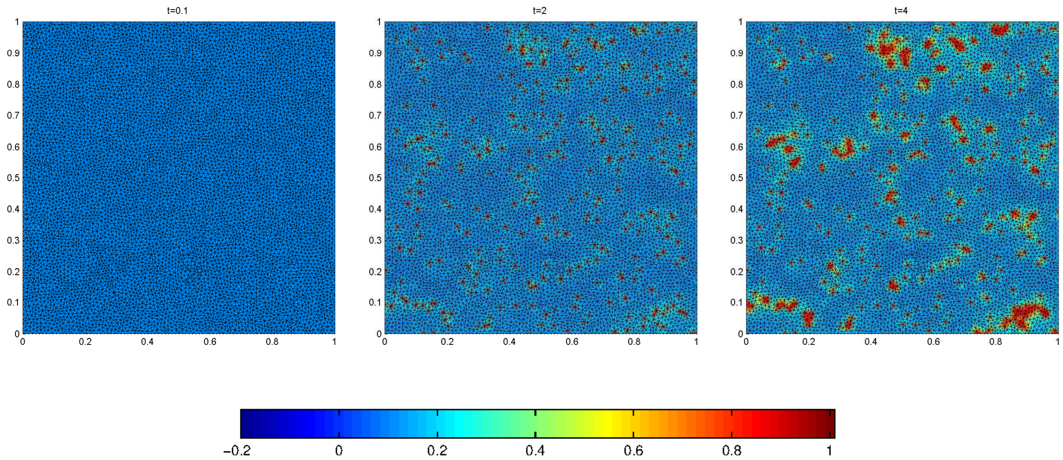

Figure 4.9: Early stage dynamics which involves 7933 neurons. For each cell, electrical synapses exist among nearest-neighbour neurons and the chemical ones are 75% of links among cells belonging to a circle having radius 1/16. The whole network is initially at rest but, after a while, a continuum external current $I = 0.1$ is applied to 319 of them randomly chosen. In the second frame, neurons which receive the injected current become apparent. In the third snapshot, a propagating phenomenon arises

Since we have considered the same topology as in Section 4.2.2, from the comparison of the dynamics, let us note that inhibitory neurons have the apparent duty of reducing neural activity. Depending on the reversal potential, inhibition can change drastically its effect and cause an excitation abort. This means that a low excitatory activity characterizes the network. However, a lower network activity is not necessarily related to strong asynchronous phenomena which would reduce the χ value. Indeed, $v_{\mathrm{syn}}^I = -0.9$ implies a strong activity reduction but it maintains an high synchronization value χ, though it is less than those in case of $v_{\mathrm{syn}}^I = -0.1$.

4.3 Mathematical analysis of the continuous model

This final section is devoted to the analysis of the mathematical properties of model (4.6), which we write here as

$$
\begin{aligned}
\frac{\partial v}{\partial t} &= \hat{f}(v,r) + I + d^*\Delta v - g_{\mathrm{syn}}\left(\int_{y\in\mathcal{B}(x)} w(x,y)s(y,t)(v(x,t)-v_{\mathrm{syn}}(y))\,\mathrm{d}y\right), \\
\frac{\partial r}{\partial t} &= g(v,r), \\
\frac{\partial s}{\partial t} &= \alpha(1-s)H_\infty(v-v_T) - \beta s,
\end{aligned}
\tag{4.9}
$$

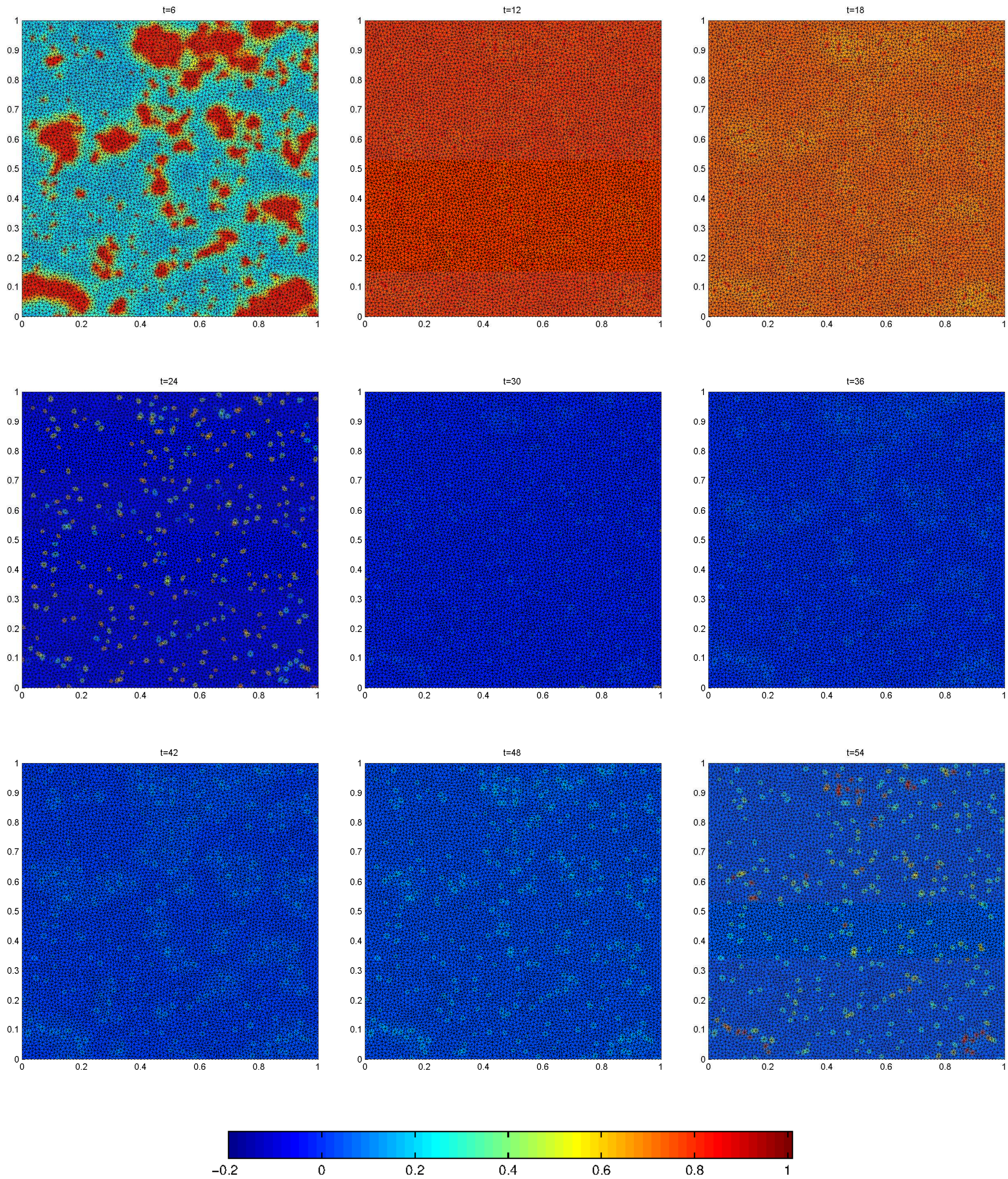

Figure 4.10: Snapshots concerning the evolution of the solution represented in Figure 4.9. In particular, the synchronous excitation phenomenon appears. It is apparent that, due to inhibitory neurons which hinder the signal transmission, the synchronization appears later than in Figure 4.7. The evolution of this dynamics is depicted in Figure 4.11

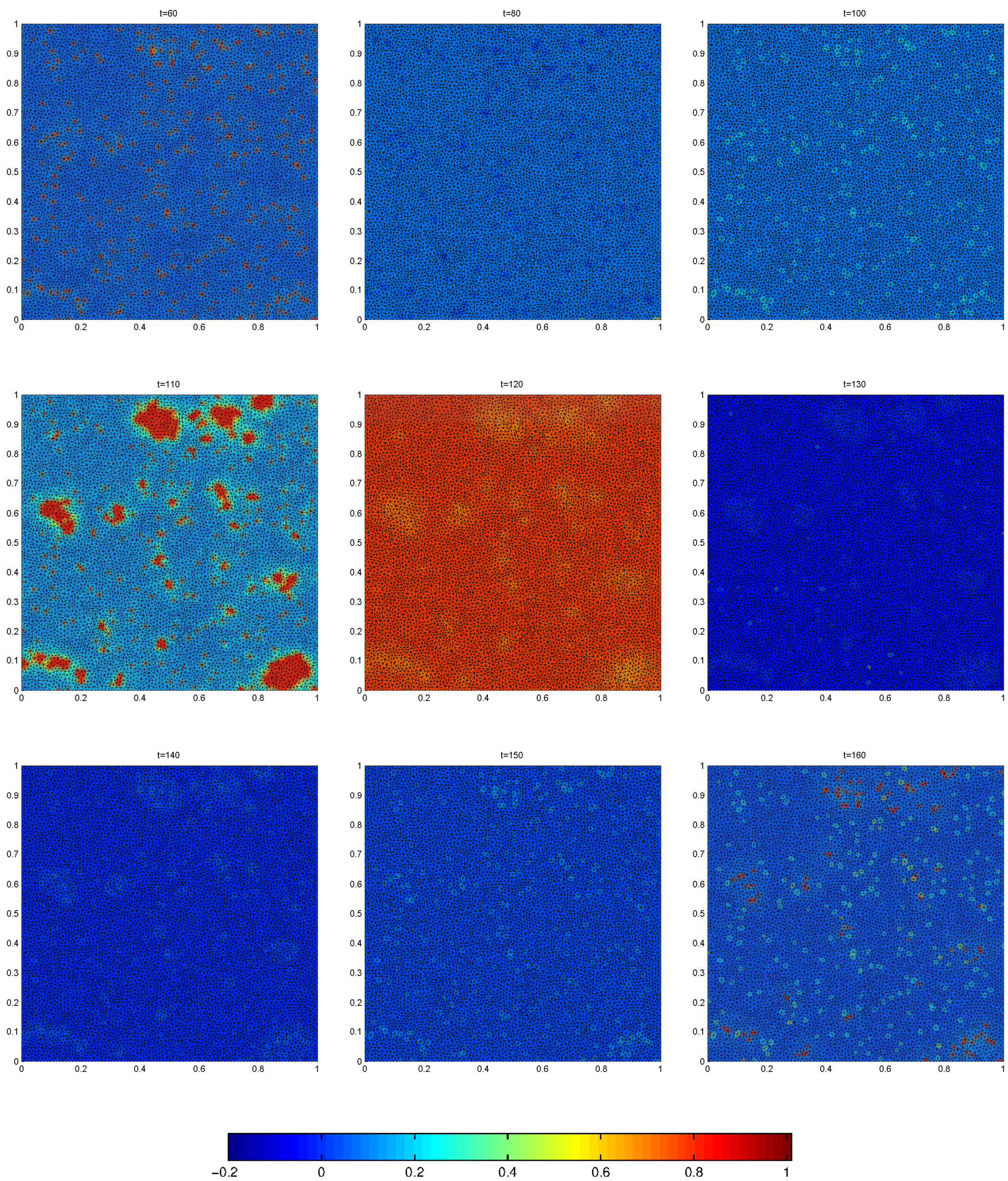

Figure 4.11: Final stages of the solution exhibited in Figure 4.9-4.10. As happened in Figure 4.8, a new synchronous event emerges due to random links which facilitate the communication between neurons in the whole domain. Of course, with respect to what happens in Figure 4.8, the synchronization emerges more later. The delay reason is the negative contribution to the excitation from the inhibitory neurons